

PATENT SPECIFICATION

DRAWINGS ATTACHED

1056,358



1056,358

Date of Application and filing Complete Specification: Oct. 18, 1963.

No. 41348/63.

Application made in Switzerland (No. 12293) on Oct. 19, 1962.

Application made in Switzerland (No. 11043) on Sept. 6, 1963.

Complete Specification Published: Jan. 25, 1967.

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Index at acceptance:—D1 B(2), 2M)

Int. Cl.:—D 06 p

COMPLETE SPECIFICATION

Improvements in and relating to the Manufacture of Colouring Compositions

We, CIBA LIMITED, a body corporate organised according to the laws of Switzerland, of Basle, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the manufacture of colouring compositions by the mixture of colouring matters in order to match the shade of a sample.

Methods have previously been proposed which make it possible to compute for a given colour sample, for example, paint of a particular shade, a bulk-dyed synthetic material or a dyed fabric, dyeing recipes which enable the sample to be reproduced or closely approached using certain known dyestuffs. If it is possible for the dyer to approximate to the given sample shade by means of one or only a few dye tests, his work can be considerably facilitated by such methods, and this is of particular importance if dyeing according to sample is a frequent necessity.

Furthermore, such a computing method would be especially valuable if it were applicable to a large number of known dyestuffs in such a way that all these dyestuffs could be combined with one another at will. The preference given to a particular dyestuff for obtaining a certain shade depends both upon the stipulated properties of fastness and on the desired shade. These stipulations and possibly economic considerations usually limit the choice of dyestuffs to be employed to a large extent, and they do so in a different way from one case to another. Generally speaking it will always be possible to find dyestuffs which meet the stipulated requirements. In most cases, however, it would be preferable to employ as the main component of the mixture

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a dyestuff that approached the shade of the sample. Thus, especially if there is such a dyestuff amongst those eligible, it would in practice be an intolerable limitation if one were compelled by the chosen computing method to obtain all shades by employing, for example, only three dyestuffs. Methods operating on this principle have nevertheless been proposed.

Methods that overcome this limitation have also been proposed. Some of them provide for the reflectance of the sample to be measured at a large number (for example, 10 to 30) of wavelengths in the visible spectrum, and for the required amounts of contemplated dyestuffs to be ascertained by calculation in such a way that equal reflectance figures are obtained for the chosen wavelengths. However, these calculations are so complex that they can only be carried out with a suitable computing device. Again, if only a small number of wavelengths (for example, only three) is employed in such a process, then the latter turns out to be too inaccurate if, as is often the case in practice, the sample contains different component dyestuffs from those to be employed in the imitation.

Hitherto, therefore, it has not been found possible to find simple colorimetric data for dyestuffs from which dyers' recipes for the dyeing of light-reflecting substrates can be computed in a comparatively simple way.

The present invention provides a process for the manufacture of a colouring composition, which comprises measuring the reflectance characteristic (a function of the wavelength), throughout substantially the whole of the visible spectrum, of a sample to be imitated and of one or more component colouring matters in known concentration, deriving from each of the reflectance characteristics, by means

of a function of the reflectance that is substantially proportional to the concentration of colouring matter, a transformed function of the wave-length that is substantially proportional to the concentration of colouring matter, replacing the reflectance characteristic in standard colorimetric integrals by the said transformed function, evaluating the resultant integrals and (in respect of the said component or components only) dividing the resulting values by the concentration of the respective component or components to give three characteristic colorimetric values for the sample and three characteristic colorimetric values for the or each component colouring matter, calculating (assuming, if there is more than one component, that the characteristic colorimetric values are additive) the concentration of the component or components required for the production of an imitation of the sample, and employing the component or components in the calculated concentration or concentrations to produce a colouring composition suitable for producing an imitation of the sample.

The reflectance characteristics of the sample and the three component dyestuffs may be measured with a spectrophotometer of any desired type. Because measurement are made throughout substantially the whole of the visible spectrum, the reflectance is determined as a continuous function R_λ of the wavelength λ .

The requirement that the said function of the reflectance is substantially proportional to the concentration of colouring matter means that the function may be either directly proportional to the concentration or such that when the function is expanded in powers of the concentration, the terms in second and higher powers of the concentration are sufficiently small to allow them to be neglected while still obtaining a satisfactory result. It is advantageously the simple Kubelka-Munk F

$$\text{where } F = \frac{(1-R)^2}{2R} \quad (1)$$

or, preferably, the modified Kubelka-Munk function F

$$\text{where } F = \frac{(1-R)^2}{2(1-r)(R-r)} \quad (2)$$

where r is the small residual surface reflectance of the substrate when dyed completely black, the said reflectance r being usually of the order of .01 to about .05. Then, if the function R of the wavelength (the reflectance characteristic) is transformed using the above formula (2), the function F_λ of the wavelength is obtained where:

$$F_\lambda = \frac{(1-R_\lambda)^2}{2(1-r)(R_\lambda-r)} \quad (3)$$

The value of r is usually dependent to some extent on wavelength, but in practice it is permissible to treat it as a constant. It should be noted, however, that the assumed value of r should under no circumstances be greater than its effective value, because the accuracy of subsequent calculations would otherwise suffer. On the other hand, if the employed value of r is somewhat below its effective value, the impairment of accuracy will usually be negligible.

Known methods, standardized by the International Commission of Illumination, employ direct integration of the reflectance characteristic itself to produce standard colorimetric values.

$$X, Y, Z = \int R_\lambda E_\lambda(\tilde{x}, \tilde{y}, \tilde{z}) d\lambda$$

herein—as it is well known in the art— E_λ represents the radiation function of the illuminant and \tilde{x} , \tilde{y} and \tilde{z} are the CIE (Commission Internationale d'Eclairage) distribution coefficients which characterise any particular colour, for example, the shade obtained when a particular material is dyed with an individual dyestuff in a certain concentration. If the reflectance characteristic R_λ is replaced in these colorimetric integrals by the transformed function F_λ and the integral is divided by the concentration K_0 of the dyestuff, new characteristic values are obtained, namely

$$L, M, N = \frac{1}{K_0} \int F_\lambda E_\lambda(\tilde{x}, \tilde{y}, \tilde{z}) d\lambda$$

which characterize the dyestuff as such and which can be regarded as being additive.

The evaluation of the colorimetric integrals may be carried out by one of the standard methods (for example, weight or selection ordinates). Preferably, calculating devices are used that are also capable of directly computing the function F_λ from the reflectance characteristic R_λ .

The characteristic values obtained are, of course, dependent upon the nature of the illumination used for the determination of the integral and, if the whole calculation is based upon only one type of illumination, for example the standard illumination C defined by the International Commission of Illumination, then there is a danger of producing metameric shades, that is to say, shades that appear identical when viewed under lighting conditions, corresponding to illumination C but not when viewed under other lighting conditions. This danger is reduced if the calculation is also carried out under at least one very different lighting condition, for example, the

standard illumination A defined by the International Commission of Illumination, and if the resultant colour values are also taken into account in computing the dyestuff composition to be used in the production of the imitation.

A valuable feature of the method is that it is possible to take into account the properties of the material to be dyed which, as a rule, is not pure white, but which is often employed in the form of a non-bleached fibre or which may be deliberately employed as a precoloured material or which may develop a slight darkening or stain as a result of treatment incidental to the dyeing operation.

The material to be dyed can be taken into account by determining in a separate operation the reflectance characteristic of the undyed material or of a blank sample which is subjected to the same chemical actions as would influence the dyed product, transforming, this (using the same function proportional to the concentration) to give a function $F_{o,\lambda}$ corresponding to the function F_λ for the dyestuff, and then replacing the function F_λ in the colorimetric integrals by the difference between F_λ and $F_{o,\lambda}$. The colorimetric values are then given by

$$L = \frac{1}{k_0} \int (F_\lambda - F_{o,\lambda}) E_\lambda \tilde{x} d\lambda$$

$$M = \frac{1}{k_0} \int (F_\lambda - F_{o,\lambda}) E_\lambda \tilde{y} d\lambda$$

$$N = \frac{1}{k_0} \int (F_\lambda - F_{o,\lambda}) E_\lambda \tilde{z} d\lambda$$

When the values l_1 , m_1 and n_1 of the sample have been ascertained in this way (preferably, for two different types of illumination), the following procedure may be adopted:

By way of a test, three dyestuffs are chosen, for example one yellow (subscript y), one red (subscript r) and one blue (subscript b), but it should be noted that when the shades are not especially pure, it would also be possible to employ some different combinations such as a yellowish red, a blueish red and a gray, provided of course that all the L, M, N-values of these shades for a given illumination are known.

Then the task of computing the requisite concentrations of the contemplated dyestuffs for the production of the imitation is reduced to the solution of three linear equations with three unknowns:

$$\begin{aligned} K_{y,1}L_y + K_{r,1}L_r + K_{b,1}L_b &= l_1 \\ K_{y,1}M_y + K_{r,1}M_r + K_{b,1}M_b &= m_1 \\ K_{y,1}N_y + K_{r,1}N_r + K_{b,1}N_b &= n_1, \end{aligned}$$

where $K_{y,1}$, $K_{r,1}$, and $K_{b,1}$ are the required

$$N = \frac{1}{k_0} \int (F_\lambda - F_{o,\lambda}) E_\lambda \tilde{z} d\lambda$$

It is an important and valuable fact that these characteristic values L, M and N can be determined once and for all and for the dyeing method to be used for the dyestuffs eligible for the dyeing operation. At is explained hereinbefore, it is advisable to determine, for example, two or more ordered triplets of characteristic values, one ordered triplet of values relating to the standard illumination C and another ordered triplet of values to the standard illumination A, which may be denoted by C_L , C_M , C_N and A_L , A_M , A_N , respectively. Thus, when computing dyers' recipes in a way which is further explained herein-after, these characteristic values may be assumed as having been calculated already.

In the computation of a dyers' recipe an advantageous procedure is first to measure the reflectance characteristic $R_{1,\lambda}$ based on the sample, to transform this with the employed function to give $F_{1,\lambda}$, and to compute therefrom the three characteristic values

$$l_1 = \int (F_{1,\lambda} - F_{o,\lambda}) E_\lambda \tilde{x} d\lambda$$

$$m_1 = \int (F_{1,\lambda} - F_{o,\lambda}) E_\lambda \tilde{y} d\lambda$$

$$n_1 = \int (F_{1,\lambda} - F_{o,\lambda}) E_\lambda \tilde{z} d\lambda$$

where $F_{o,\lambda}$ is the transformed reflectance function of the fabric that is to be dyed.

Integrals may be evaluated as the difference of two integrals, thus:

concentrations of the yellow, red and blue dyestuffs, respectively.

As it is possible—of course with certain exceptions—to match a given sample by means of widely different dyestuff combinations, whereby according to the selection of the dyestuffs only metameric dycings may result which, depending on the illumination, may differ from the sample to an undesirable extent, it is often advisable in order to avoid this effect to compare the remission curve of the sample with the remission curves of the intended dyestuffs, and to select such dyestuffs the maxima of which and minima are situated at similar points of the spectrum and possibly even process similar shapes as compared with the remission curve of the sample. Although such a purely qualitative estimation can not give any indication concerning the quantities of the dyestuffs to be used it may be useful for selecting the dyestuffs.

If the possibility of metamerism is neglected or if metamerism can be expected to be small, then the computation of the concentrations of the component dyestuffs in the com-

- position for use in the production of the imitation is complete. It is, however, advisable to solve the corresponding equations containing characteristic values obtained by using a different light source to give the following values (the superscripts A and C referring to the illumination conditions):

$$A_{y,1}, A_{r,1}, A_{b,1} \text{ and } C_{y,1}, C_{r,1}, C_{b,1}$$

- If the vertically read values are approximately equal (that is to say, if $A_{y,1} \approx C_{y,1}$ etc.) to start with, then the task can be regarded as solved. Otherwise, the calculation can be carried out for other dyestuffs of which the characteristic values are likewise available, until the desired coincidence is achieved.

- In simple cases the solution thus obtained may be sufficient. It is, however, advisable to make a dyeing test in any case with the calculated dyestuff concentrations

$$K_{y,1}, K_{r,1} \text{ and } K_{b,1}$$

- under the contemplated dyeing conditions, and to compare this test with the sample.

- If the dyeing test No. 1 thus obtained, should for some reason not coincide with, or approximate sufficiently closely to, the sample, then the errors still inherent in the computed values $K_{y,1}$, $K_{r,1}$ and $K_{b,1}$ can be ascertained by applying the same measuring and computational procedure to the test product. Thus, the test product is subjected to the same metric operation as had previously been applied to the sample, and new values are established therefrom which are now given the subscript 2:

$$l_2, m_2, n_2.$$

From this, new concentration values

$$K_{y,2}, K_{r,2}, K_{b,2}$$

- are obtained by solving the corresponding set of linear equations. These new concentration values usually turn out to be slightly different from the originally calculated values

$$K_{y,1}, K_{r,1} \text{ and } K_{b,1}.$$

- The ratios

$$\frac{K_{y,1}}{K_{y,2}} = f_y, \frac{K_{r,1}}{K_{r,2}} = f_r, \frac{K_{b,1}}{K_{b,2}} = f_b$$

- are then found and, especially when the various quantities f_y , f_r , f_b are approximately equal to unity (they may be smaller or greater than unity), a closer approximation to the desired

concentration values may be obtained by multiplying the originally calculated concentration values

$$K_{y,1}, K_{r,1} \text{ and } K_{b,1}$$

by the quantities f_y , f_r and f_b , respectively.

If necessary, the corrective process may be iterated.

The value of the correction factors f_y , f_r and f_b may differ from unity to an appreciable extent in certain circumstances, especially with regard to textile treating agents, bath ratio, temperature characteristic, affinity of the dyed material to the several dyestuffs etc. from the process by which the shades of the individual dyestuff were obtained and on which the bulk dyeing process is based. It is therefore advisable to collect correction factors systematically and to take them into account when computing the concentration values for the first dyeing operation.

The method of the invention is not confined to dyeing operations using mixtures of three dyestuffs. It also serves for computing recipes for binary mixtures, and for computing the concentration of a single dyestuff if, in exceptional cases, a sample can be matched with only one or two dyestuffs.

On the other hand, it is also feasible with this method to compute dyeing recipes comprising more than three components in the following cases:

(a) When the mixture ratio of two or more dyestuffs is given, this can be done by calculating the complementary color values of the mixture of these component and computing the recipe in accordance with the method of the invention, the calculated mixture being one of the three components. This case is of importance, for example, if it is desired to reduce the metamerism of the imitation shade in relation to that of the sample by employing more than three dyestuffs.

(b) When certain concentrations of one or more dyestuffs are given, this can be done by deducting the complementary color values of these given components from the color values of the sample and carrying out the computation for the differential complementary color values. This case is of importance if a certain dyestuff is to be employed with a predetermined concentration (for example, for reasons of price or fastness, infrared properties etc.) and the sample cannot be matched with only two further components.

A process for the manufacture of a dyestuff composition in accordance with the invention will now be described by way of example in greater detail with reference to the accompanying drawings in which:

Fig. 1 is a graph showing the percentage reflectance R as a function of wave-length;

Fig. 2 is a graph showing the values of a

transformed function F as a function of wave-length; and

Fig. 3 is a graph used in the computation of the composition.

- 5 The reflectance characteristic of a substrate dyed with a green reactive dyestuff processed according to the thermal fixing method with 10 grams per liter of padding liquor and a squeezing effect of 60% is determined in known manner and is represented

$$F = \frac{(1 - R_2/100)^2}{1.96 (R_2/100 - 0.02)} - \frac{(1 - R_1/100)^2}{1.96 (R_1/100 - 0.02)}.$$

- 25 The colorimetric values are measured according to standard methods for the standard illumination C , and are then divided by the concentration $K_0 = 10$ grams per liter. The final result is

$$\begin{aligned} L &= 0.1801 \\ M &= 0.0976 \\ N &= 0.1357 \end{aligned}$$

(for wave-lengths within the range of from 400 $m\mu$ to 700 $m\mu$) by the curve 2 in Fig. 1 of the drawings. The reflectance of the undyed substrate is similarly determined and is represented over the same range of wave-lengths by the curve 1 in Fig. 1. Denoting the reflectance of the undyed substrate by R_1 and the reflectance of the dyed substrate by R_2 , the modified Kubelka-Munk function is used to form a new function,

the relevant units being liters per gram.

If it should emerge that, for particular substrates, dyestuffs or dyeing processes etc., another function that is proportional to concentration gives a more satisfactory result than that given by the Kubelka-Munk function, then, for example, the functions of

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may without difficulty be used instead of the Kubelka-Munk function.

- 40 As is apparent from the above description, it is quite feasible to carry out the required transformations and calculations by hand or with generally known aids, especially if it is remembered that the characteristic colorimetric values for the dyestuffs to be employed can be fixed once and for all.

- 45 It is of course of great advantage to have available computing devices which can take care of the conversion into numerical values and of the computations. For example, devices are known for solving three linear equations with three unknowns. A unit which employs the modified Kubelka-Munk function and serves for computing the characteristic values as well as the values l , m and n of both sample and dyeing tests forms the subject of another patent application, No. 41313/63.

- 60 The solution of the three mixture equations containing the three dyestuff concentrations as the unknowns can be carried out with the aid of a desk-type computer (matrix inversion) or with the aid of an analogue computer especially equipped for this task.

- 65 An especially simple way of ascertaining the dyestuff concentration is the graphic method. For this purpose, the following values must be calculated for each dyestuff:

$$S = L + M + N$$

- 70 and the complementary colorimetric values

$$x_s = L/S; y_s = M/S,$$

and, for the sample and the limitations, respectively:

$$s = l + m + n$$

and the complementary colorimetric values

$$x_s = l/s; y_s = m/s,$$

The values x_s and y_s of a range of dyestuffs are plotted in a diagram as the abscissae and the ordinates, so that each dyestuff is represented by a point. Such diagrams may for example be duplicated by the dyestuff manufacturer and issued to dyers. The values x_s and y_s of the sample are then entered on these diagrams (see Fig. 3). A sample can be imitated with three such dyestuffs if the point representing the sample is situated within the triangle formed by the three dyestuff points. In order to determine the concentrations, the values

$$p_y = \frac{u_y}{u_y + v_y}; p_r = \frac{u_r}{u_r + v_r}; p_b = \frac{u_b}{u_b + v_b} \quad 90$$

are measured with a ruler and calculated, or found directly with the aid of a template developed specially for the purpose.

The concentrations of the first combination achieved will then be

$$K_{y,1} = \frac{s_1}{S_y} p_y$$

$$K_{r,1} = \frac{s_1}{S_r} p_r$$

$$K_{b,1} = \frac{s_1}{S_b} p_b$$

As stated hereinbefore, the dyer himself

does not usually have to determine the characteristic values for dyestuffs to be employed by the colorimetric evaluation of shades achieved with those particular dyestuffs, because these values are characteristic of the dyestuffs and may, for example, be indicated by the manufacturer. In order further to simplify his task, however, the dyer can use a color atlas in which a large number of hues are to be found.

Some such color atlases are on the market, for example DIN or Munsell. To render them usable in connection with the present method, it is necessary to determine, once and for all, the characteristic values of the samples contained in the atlas. Then the dyer can compare the sample which he must copy with the samples of the color atlas and use the characteristic values of the nearest sample from the atlas, or introduce a further improvement by interpolation, should the sample be found to lie between two samples of the atlas.

It is also possible to accomplish the correction methods that are described hereinbefore when using such an atlas, because basically

there is no difference between determining the characteristic values of the sample to be copied directly and determining them indirectly by comparison with a sample already evaluated. The dyer still has the advantage of being able to select such dyestuffs as seem useful to him and of being able to obtain, by the solution (repeated if necessary) of three equations with three unknowns, the required quantities of dyestuffs.

Since it is not necessary, when a color atlas is used, to measure the characteristic values L, M, N it would be desirable also to be able to carry out the correction of the first imitation without having to measure the characteristic values l, m, n. Since the Kubelka-Munk function, to a first approximation, is inversely proportional to the reflectance, an approximate correction of the characteristic values of the sample can be calculated by using the reciprocal values of the standard color values (tristimulus values) of the sample as well as those of the first imitation.

Thus,

$$\begin{aligned}
 l_{\text{corr}} &= l_{\text{sample}} \frac{\frac{1}{X_{\text{sample}}}}{\frac{1}{X_{\text{first imitation}}}} = l_{\text{sample}} \frac{X_{\text{first imitation}}}{X_{\text{sample}}} \\
 m_{\text{corr}} &= m_{\text{sample}} \frac{Y_{\text{first imitation}}}{Y_{\text{sample}}} \\
 n_{\text{corr}} &= n_{\text{sample}} \frac{Z_{\text{first imitation}}}{Z_{\text{sample}}}
 \end{aligned}$$

The approximate standard colorimetric values can be determined, for example, by means of a suitable simple three-filter photometer.

If a color atlas is used for calculating the recipe, the unknown characteristic values of the sample are replaced by the characteristic values l_{atlas} , m_{atlas} , n_{atlas} of the nearest color sample in the atlas.

This method of correction is especially valuable for the standard recipe procedure if the dyer cannot determine the characteristic values l, m, n himself, but has this done elsewhere.

As the problem involved in non-textile dyeing problems, for example, in the preparation of colored lacquers and paints, is always the same as that involved in textile dyeing viz. to determine the amounts of dyestuffs or pigments to be mixed in order to match a given sample it is obvious that the present process can be used as well for solving non-

textile problems. It goes without saying that a standard test must be fixed for the testing of paints for example, because the values of L, M and N, which are typical for given dyestuffs are dependent on the dyeing or painting process to be used as a paint may look different depending on its thickness and on the base on which it is applied, in the same way as a textile dyeing made according to the padding method certainly depends on the squeeze effect actually applied.

EXAMPLE

A sample of beige shade on wool was to be imitated on cotton by means of reactive dyes. According to the method described in connection with Fig. 1, the characteristic colorimetric values l, m and n of the sample and of the fabric to be dyed were determined and the difference was used for calculating the recipe.

The following values are obtained

	l	m	n
Sample	1.665	1.627	5.909
Fabric to be dyed	0.008	0.007	0.018
Difference	1.657	1.620	5.891

The three dyestuffs were:

	L	M	N
A brown	0.1008	0.0926	0.4275
A pure red	0.1602	0.3811	0.2396
A pure blue	0.1705	0.1468	0.0319.

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For the graphic determination the following values were calculated:

Sample	s	x_s	y_s
	9.168	0.1808	0.1767

5 For the dyestuffs to be used the corresponding values L, M and N had been determined in an analogous way. The dyestuffs were selected in such a way as their combination gave a good replica of the remission curve of the sample.

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Dyestuffs	Brown (y)	S	x_s	y_s
	Red (r)	0.7809	0.2051	0.4880
	Blue (b)	0.3492	0.4881	0.4205.

25 A diagram was made wherein the point with the co-ordinates x_s and y_s and the three points with the co-ordinates x_s , y_s for brown (y), red (r), and blue (b) were fixed.

As indicated in Fig. 3 the values u_y , v_y , u_r ,

v_r , u_b and v_b were measured and the values p_y , p_r , and p_b as well as $K_{y,1}$, $K_{r,1}$ and $K_{b,1}$ were calculated according to the formulae given hereinbefore.

30

	u (mm)	v (mm)	p	K_1 (g/l)
Brown (y)	165.5	16.5	.909	13.40
Red (r)	6.3	156.2	.0388	0.46
Blue (b)	11.0	196.0	.0531	1.40.

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40 A first imitation was made by means of the concentrations $K_{y,1}$, $K_{r,1}$ and $K_{b,1}$ of the three dyestuffs. Its shade was approximately the same as the shade of the sample but the dyeing was somewhat too weak. This was confirmed by the measured colorimetric values

	l	m	n
Sample minus substrate	1.657	1.620	5.891
corrected values	1.788	1.718	6.305

For the graphic determination the necessary values were calculated as follows:

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	X	Y	Z
Sample	.2650	.2393	.0981
First imitation	.2860	.2537	.1050

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	s	x_s	y_s
Corrected values	9.811	.1823	.1751.

50 By means of these colorimetric values of the sample and of the imitation and by means of the characteristic values of the sample the corrected characteristic values for the second imitation were determined according to the method for correction given above

The corrected values x_s and y_s were again inserted in the diagram. By measuring the corrected values u and v and the concentrations as corrected for the second imitation $K_{y,2}$, $K_{r,2}$ and $K_{b,2}$ were determined as follows:

60

	u (mm)	v (mm)	p	K_2 (g/l)
Brown (y)	171.0	16.0	.914	14.44
Red (r)	4.5	157.0	.0279	0.35
Blue (b)	12.2	195.8	.0587	1.65

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70 The second imitation was made with these corrected concentrations $K_{y,2}$, $K_{r,2}$, $K_{b,2}$.

As shown by the measured colorimetric values, it was in good accordance with the sample

	X	Y	Z
Sample	.2650	.2393	.0981
First imitation	.2860	.2537	.1050
Second imitation	.2660	.2408	.0998.

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WHAT WE CLAIM IS:—

1. A process for the manufacture of a colouring composition, which comprises measuring the reflectance characteristic (a function of the wavelength), throughout substantially

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the whole of the visible spectrum, of a sample to be imitated and of one or more component colouring matters in known concentration, deriving from each of the reflectance characteristics, by means of a function of the reflectance that is substantially proportional to the concentration of colouring matter, a transformed function of the wave-length that is substantially proportional to the concentration of colouring matter, replacing the reflectance characteristic in standard colorimetric integrals by the said transformed function, evaluating the resultant integrals and (in respect of the said component or components only) dividing the resulting values by the

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concentration of the respective component or components to give three characteristic colorimetric values for the sample and three characteristic colorimetric values for the or each component colouring matter, calculating (assuming, if there are more than one component, that the characteristic colorimetric values are additive) the concentration of the component or components required for the production of an imitation of the sample, and employing the component or components in the calculated concentration or concentrations to produce a colouring composition suitable for producing an imitation of the sample.

2. A process as claimed in claim 1, wherein the said function of the reflectance is the Kubelka-Munk function.

3. A process as claimed in claim 1, wherein the said function of the reflectance is the Kubelka-Munk function modified to take into account the residual surface reflectance.

4. A process as claimed in any one of claims 1 to 3, wherein the reflectance characteristic of the substrate to be coloured is measured, there is derived from the reflectance characteristic, by means of the said function of the reflectance, a transformed function of the wave-length and this transformed function is subtracted from the transformed function relating to the or each component colouring matter prior to integration or a characteristic colorimetric value is obtained for the undyed substrate and then subtracted from the characteristic colorimetric value for the or each component colouring matter.

5. A process as claimed in any one of claims 1 to 4, wherein, in order to avoid metameric shades, characteristic colorimetric values are determined for the or each component colouring matter and for the sample using at least two appreciably different types of illumination.

6. A process as claimed in claim 5, wherein the said two different types of illumination are those designated A and C by the International Commission of Illumination.

7. A modification of the process as claimed in any one of claims 1 to 6, wherein the characteristic colorimetric values of the sample are indirectly determined by comparison of the sample with the samples of a colour atlas of which the characteristic colorimetric values are known.

8. A process as claimed in any one of claims 1 to 7, wherein the equation or system of equations giving the concentration of the or each component colouring matter to be used

in the production of the imitation is solved graphically by using a diagram showing the complementary colorimetric values of the colouring matters, the complementary colorimetric values of the sample being plotted thereon.

9. A process as claimed in any one of claims 1 to 8, wherein an imitation is produced by using the colouring composition to colour a substrate and the measuring and computational procedure is applied to the imitation to yield characteristic colorimetric values of the imitation, the value of the concentration of the or each component colouring matter is corrected to take into account differences between the corresponding characteristic colorimetric values of the sample and the imitation, respectively, and the or each component colouring matter is employed in the corrected concentration to produce an improved imitation.

10. A process as claimed in any one of claims 1 to 8, wherein an imitation is produced by using the colouring composition to colour a substrate and, for the purpose of obtaining corrected concentration values, the standard colour values (tristimulus values) of the sample and the imitation are determined, and an approximate correction is carried out using the reciprocal values of the standard colour values, instead of the said characteristic colorimetric values, and the or each component colouring matter is employed in the corrected concentration so obtained to produce an improved imitation.

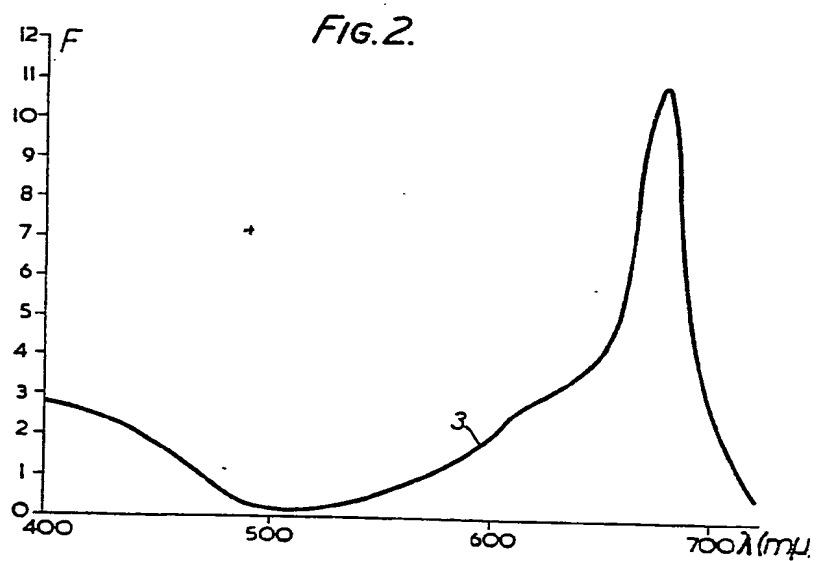
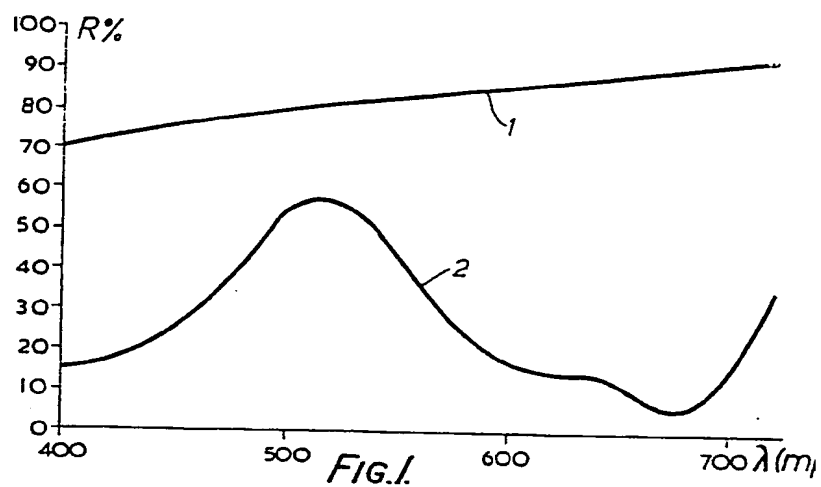
11. A process as claimed in claim 9 or claim 10, wherein the correction procedure is iterated.

12. A process as claimed in any one of claims 1 to 11, wherein three component colouring matters are used to produce the colouring composition.

13. A process for the manufacture of a colouring composition substantially as hereinbefore described.

14. A process for the manufacture of a colouring composition substantially as described in the Example herein.

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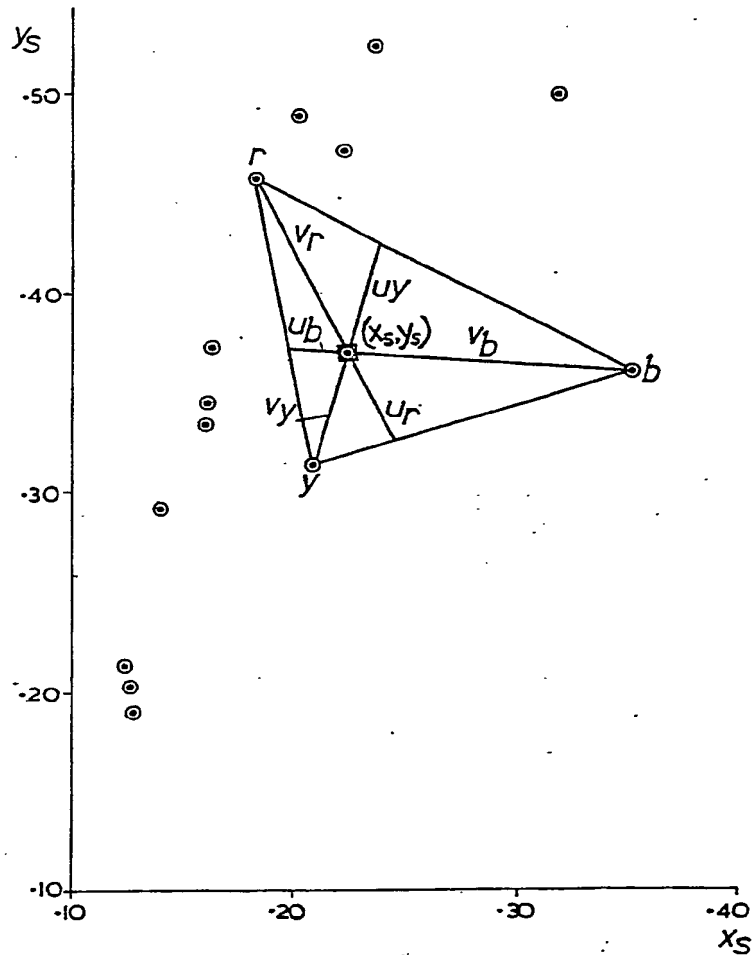


FIG. 3.

1056358 COMPLETE SPECIFICATION
2 SHEETS
This drawing is a reproduction of
the Original on a reduced scale
Sheets 1 & 2

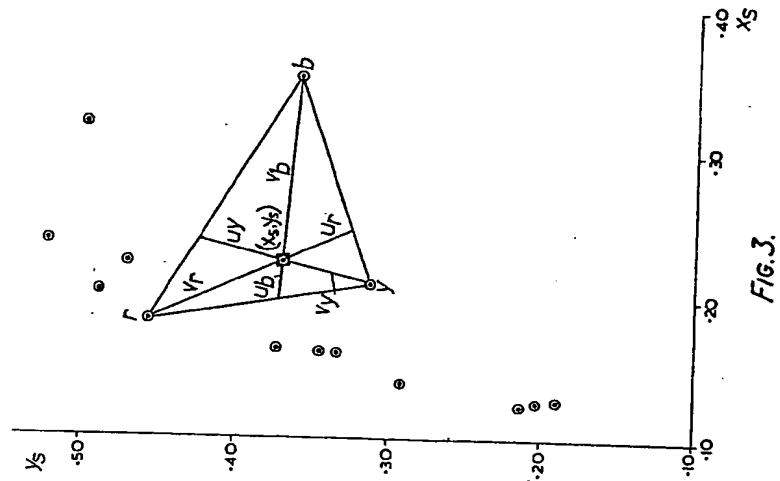
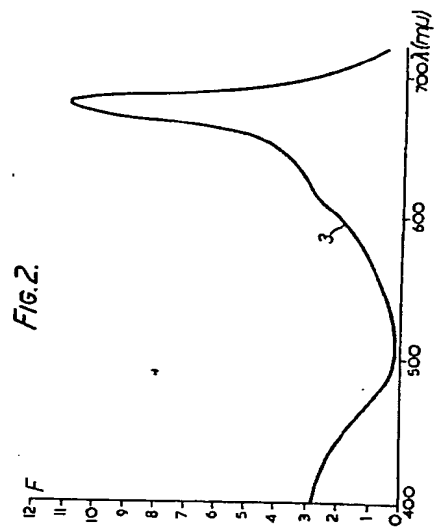
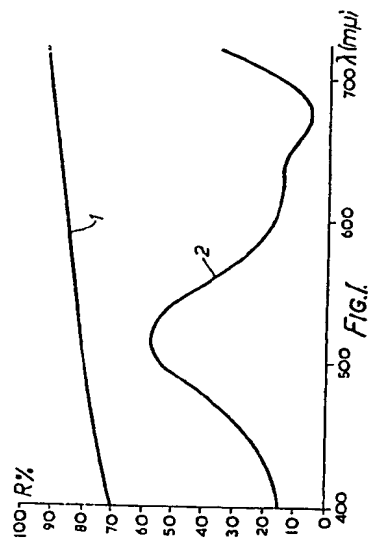


FIG. 3.

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